III Groundwater Characteristics

OBJECTIVES

A Explain why groundwater is nearly the same cool temperature all year.

B Discuss the origin of hot springs, including paint pots, geysers, and fumaroles.

C Discuss the origin of minerals in groundwater and list some factors that control the mineral content of groundwater.

Topic 13 Groundwater Is Usually Cool

At a depth of up to 20 meters under the surface, soil and rock are protected from weather changes. The temperature at that depth remains the same all year. That temperature is the same as the average annual temperature at that location. In most parts of the United States, the average temperature is between 5°C and 15°C. The water of an ordinary well or spring is close to the same temperature as the ground around it. Therefore, the water is relatively cool in summer and does not freeze in winter. In polar regions, where the average temperature is below freezing, there can be no wells or springs, for the water in the ground is always frozen. This permanently frozen ground, which may be hundreds of meters deep, is called *permafrost.*

Topic 14 Hot Springs, Geysers, and Fumaroles

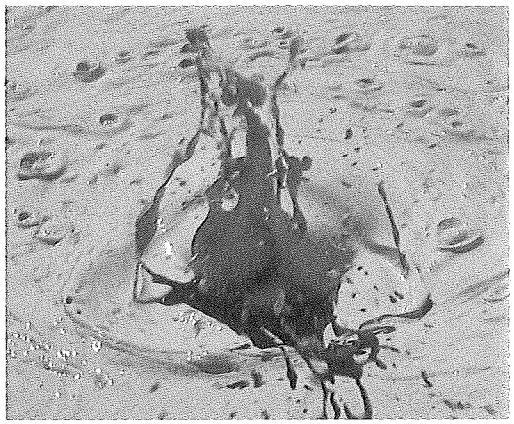
Below the 20-meter depth, heat from Earth's interior raises underground temperatures at the rate of about 1°C for every 40 meters of depth. Water from deep artesian wells or springs may therefore be much warmer than water from ordinary wells or springs. Fissure springs that originate a thousand meters below the surface may be warm springs or even hot springs, such as those at Warm Springs, Georgia, or Hot Springs, Arkansas.

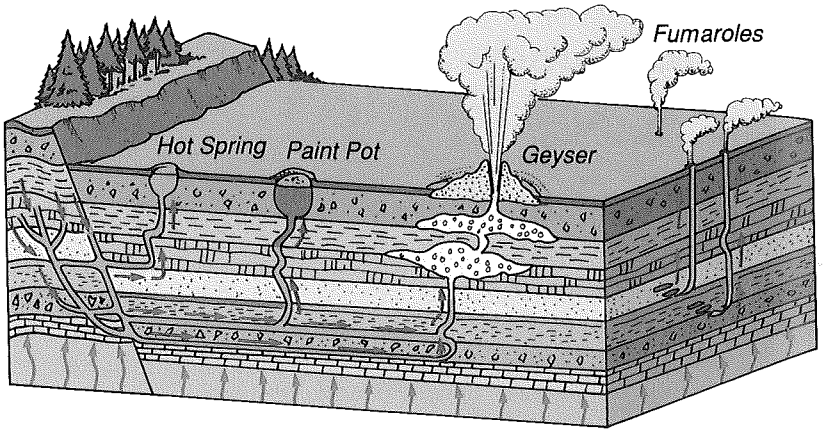
Groundwater may be hot without coming from great depth. In many regions of recent volcanic activity, igneous rock near the surface is still hot enough to boil water. In such places the groundwater may come to the surface as boiling hot springs. If the hot water comes up through thick, sticky clays, the result is a sputtering spring called a *paint pot*, or mud volcano.

Geysers are boiling hot springs that periodically erupt as gushers of hot water and steam. There are only a few places in the world where geysers occur. The most familiar may be Yellowstone National Park in Wyoming. Old Faithful in Yellowstone is famous for both its height and its frequency. The average time between its eruptions is about 85 minutes. An eruption lasts several minutes and reaches a height of 45 meters or more.

Why does a geyser erupt violently, instead of simply overflowing as an ordinary hot spring does? The difference seems to be that the ordinary hot spring rises from its source through a wide tube. The geyser's tube, in contrast, has one or more constrictions, such as a partly blocked water pipe, that interfere with the upward flow of heated water. Because of the constriction, the water at the bottom

9.11 This paint pot is a hot spring that reaches the surface through sticky clays formed by weathering.





9.12 Heating and pressurization of groundwater causes geothermal phenomena, such as geysers, hot springs, and fumaroles. Red arrows represent heating. Blue arrows represent pathways for groundwater and steam.

of a geyser's tube is under pressure. It becomes superheated to a temperature far above its surface boiling point but does not yet turn into steam because of the pressure. When steam eventually does form, it forces its way up the tube and pushes some of the superheated water up to the surface. The pressure at the bottom of the tube is relieved, and the superheated water explodes into steam. The steam blows out the water above it, and the geyser erupts.

Fumaroles (FEW muh roles) are fissures in the ground from which steam and hot gases escape. They are found in volcanic regions where fairly recent eruptions have occurred. A fumarole field is the source of the geothermal energy at the Geysers in California (Chapter 6, Topic 20). Other commercial fumarole fields are located in Italy, Japan, Iceland, New Zealand, Mexico, and the Soviet Union.

Topic 15 The Minerals in Groundwater

The water in clouds and in rain comes from water that evaporated from Earth's oceans and land. When water evaporates, it leaves impurities behind. Therefore, rainwater contains almost no dissolved mineral matter, although it may contain dissolved gases and liquids. When rainwater seeps into the ground, however, the situation changes. As groundwater passes through the lower soil layers or bedrock, it dissolves minerals. Much of the dissolved mineral matter remains in the groundwater. The kind of rock through which water passes, the distance the water travels underground, and the water temperature all affect the kind and amount of mineral matter dissolved in groundwater.

Hard water contains a substantial amount of ions that were dissolved from mineral matter. The ions are usually calcium, magnesium, or iron. Of these ions, calcium (from calcite) is the most common cause of water hardness. The dissolved minerals in hard water interfere greatly with its use. In laundering, these minerals react with soap to form scum instead of suds. In boiler tubes and hot-water pipes, dissolved minerals form deposits called boiler scale.

Artesian water is usually harder than ordinary groundwater. Artesian water travels farther and may be warmer, so it can dissolve more mineral matter than ordinary groundwater. By contrast, ordinary groundwater is almost always harder than river water. Because limestone is largely calcite, almost all the water is hard in regions that have limestone bedrock.

Topic 16 Mineral Springs

A spring containing so much dissolved mineral matter that it cannot be used for ordinary drinking or washing purposes is called a *mineral spring*. The high mineral content of the water may be due to any of the following factors:

1. The water passes through very soluble rock (such as the salt beds in Michigan).
2. The water contains large quantities of gases that form acids when mixed with water, such as carbon dioxide (Saratoga Springs, New York) or hydrogen sulfide (White Sulphur Springs, West Virginia).
3. The water is very hot (Hot Springs, Arkansas). Minerals dissolve better in hot water than in cold water. Therefore, water from hot springs usually has a high mineral content. When the hot water cools at the surface, some of the mineral matter is deposited around the spring. Such deposits are discussed in Topic 19.

Many mineral spring areas have become health resorts. In desert regions, however, alkali (bitter) mineral springs may be poisonous. In the southwestern United States, for example, alkali springs may carry borax, sodium carbonate, and sodium sulfate in solution.

TOPIC QUESTIONS

Each topic question refers to the topic of the same number.

13. **(a)** Why do spring water and well water stay cool in summer? **(b)** Why doesn't well water freeze in winter months? **(c)** What is permafrost?

14. **(a)** Why is the water of very deep artesian wells warmer than ordinary well water? **(b)** Explain the heat source of boiling hot springs and geysers. **(c)** What is a paint pot? **(d)** What causes a geyser? **(e)** What is a fumarole?

15. **(a)** What factors determine the amount and kind of mineral matter dissolved in groundwater? **(b)** What is hard water? **(c)** Compare the hardness of water in ordinary wells, artesian wells, and rivers. **(d)** Why is all the water hard in a limestone region?

16. What three factors cause a high mineral content in a mineral spring?